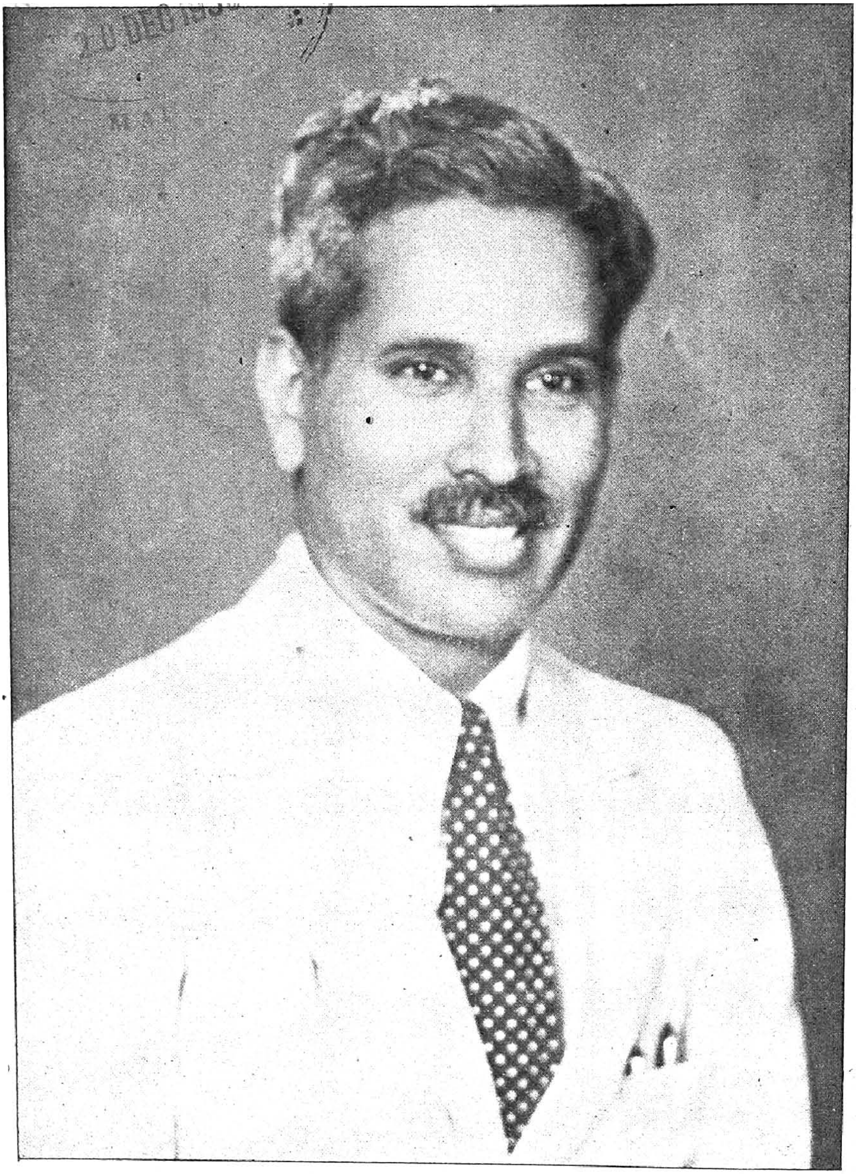

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JOURNAL

OF THE ELECTRICITY DEPARTMENT GOVERNMENT OF MADRAS

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NOTES FOR THE GUIDANCE OF AUTHORS OF ARTICLES CONTRIBUTED FOR THE JOURNAL

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High Voltage Test on Alternators

By V. P. APPADURAI, B.A., M.I.E. (IND.),
Chief Engineer for Electricity.

THE NOTE below indicates the practice of high potential testing of alternators and other rotating machinery at works and at site either before commissioning or after overhauls.

It may be mentioned that there are two distinct schools of thought on routine high voltage testing : one takes the stand that routine tests disclose weak insulation and thus prevent breakdowns later, at perhaps critical periods. The other holds that good apparatus is often broken down by repeated application of high voltages and more than likely, the apparatus would have continued in service indefinitely but for the tests.

Some supply undertakings like the Shawinigan Water and Power Co. and the Hydro-Electric Power Commission of Ontario make the high voltage testing of machines an annual routine, while it is not the policy of the Tennessee Valley Authority to conduct such routine high voltage tests on electrical apparatus.

D.C. testing equipment has to indicate only the resistance leakage current whereas an A.C. testing equipment has to furnish also a large capacitance current. With D.C. testing the leakage current involved is very small, not exceeding a few milli-amps, so that the testing equipment can be compact and easily portable. Consequently for testing large machines, the D.C. testing equipment is much smaller and costs less than A.C. testing equipment.

A.C. and D.C. over-potential tests produce somewhat different dielectric conditions in the winding. The A.C. test produces a dielectric loss in the insulation and it may produce some corona. The D.C. test produces a different type of corona and increased creepage stresses. The potential distribution on the end portion of the windings depends on resistance for the D.C. test and mostly on capacitance for the A.C. test. Hence on the winding end portion situated at short distances from the magnetic core, the D.C. test will stress the insulation more than the A.C. test. A.C. over-potential testing usually involves no current measurement and therefore must be destructive to detect faults. On the other hand, in D.C. testing the leakage current is measured easily. Further, the leakage current is not masked by the capacitance current as is the case with A.C. testing. With D.C. over-potential testing, the voltages which are equally searching for defects and damages are far less harmful than the equivalent alternating voltages.

To puncture various types of undamaged insulation a D.C. voltage of about 1·5 to 3 times the RMS A.C. voltage is required. This ratio does not apply to the voltage strength of various creepage sufaces of rotating machines in service. Thus a conservative D.C. test voltage would be slightly above $\sqrt{2}$ times the A.C. RMS test voltage.

Charging KVA

Approximate charging KVA of 13,800 volt synchronous machine windings with class B insulation with 19,000 volts (RMS) applied at 60 cycles:

Winding stated KVA.	*Approximate charging KVA for entire winding at 60 cycles.*				
	100 *RPM.*	300 *RPM.*	900 *RPM.*	1,800 *RPM.*	3,600 *RPM.*
2,500 ..	25	17	12	10	8
5,000 ..	40	28	20	16	13
10,000 ..	70	48	34	27	20
25,000 ..	140	100	65	53	40
50,000 ..	230	160	110	90	70
100,000 ..	390	270	190	150	120

NOTE.—If only one phase of a three-phase winding is tested, the charging KVA will be approximately 40 per cent of these values.

Maintenance over-potential tests.

Test voltage for armature windings in service in terms of E, rated voltage of machine. (After inspection, cleaning and drying.)

Test.	*A.C. (RMS) test voltage.*	*D.C. test voltage.*
1. Before replacement coils or bars are installed.	1-1/3 E + 600	2 E + 1000
2. After replacement coils or bars are installed.	1-1/4 E + 500	1-7/8 E + 800
3. Suitability for service	1-1/5 E + 400	1-3/4 E + 600

For large class B insulated armature windings, some users prefer a 10 per cent higher test voltage than that given in the above tables.

Before a service over-potential test is applied, the windings should be given a thorough visual inspection, cleaned if necessary, and the insulation resistance checked. If some replacement coils are to be installed, tests (1) and (2) are used; if it is desired to apply a moderate over-potential test to a winding to determine its suitability for continued service, test (3) is used.

The frequency of over-potential testing depends on service conditions. Some operators find it expedient to apply a maintenance over-potential test every one or two

years to coincide with the over-hauling programme.

Testing equipment should have ample capacity, adequate voltage stability, and a voltage which is relatively free from harmonics. If a D.C. test is used, it is important to ground the winding for a sufficient time, at least 60 minutes, to completely remove the electrostatic charge.

The recommended practice for maintenance over-potential testing of machine windings should aid in standardizing the test for windings in service on the same lines as the standard proof test for new windings.

The practices in various power Utilities are given below :—

1. *Messrs. American Gas and Electric Supply Corporation.*—They give their machines a high potential test after repairs, the test voltage not to exceed 1½ times the operating voltage of the machine and they use A.C. for testing purposes.

2. *Hydro-Electric Power Commission of Ontario.*—They are of the view that the cumulative effect on life of the repeated A.C. high potential tests is very small when reasonable values of voltage and time are used, such as, for example, a voltage to ground of 1·5 times rated line-to-line voltage, applied for one minute.

Their preference for D.C. tests is based, firstly, on some valuable additional information which they were able to obtain from their research and secondly, on the ready portability and small KVA requirements of the D.C. testing equipment, and the consequent economies.

The use of D.C. tests lasting half a day to one day gives the following information :—

(*a*) A high probability of determining the electric strength of the weakest point of winding without doing any damage to the winding. If desired, the machine can then be returned to service and repaired when convenient.

(*b*) A valuable indication of the useful life remaining in the winding, by comparison with the specific absorptions or discharges of windings in known conditions.

The latest indications of such tests are that the safest breakdown predictions are obtained when the machine is at room temperature, and before any cleaning has been done on the stator winding.

For acceptance testing of new machines, well dried out, before service, the following test voltages are used :—

An A.C. r.m.s. voltage of 2E + 1,000 V for one minute.

A D.C. voltage of 1·4 or 1·5 (2E + 1,000 V) for one minute.

For routine testing after some service, the following are used :—

An A.C. r.m.s. voltage of 1·5 E for one minute.

A D.C. voltage of 2·1 E to 2·2 E for as long as required to attain steady conduction current (e.g., 30 KV. D.C. for 13·8 KV machines : or 25 KV. D.C. for 11 KV machines).

3. *The Shawinigan Water and Power Company.*—The Power-house generators (13·8 KV) are tested to 5,000 V to ground, one phase at a time, with the other two phases grounded for one minute. This is done twice a year. Testing after major repairs to windings is done

up to 10 KV to ground and between phases. Tests between phases are done at least once a year.

The generator field winding is tested at 600 V to ground, this test to include field breaker, rheostat and cable. *A.C. is used for all testing.*

4. *Messrs. Consolidated Edison Company of New York.*—It has been their practice to make D.C. tests on the stator windings on a routine basis for the reason that they have found it impractical to set up A.C. test equipment of sufficient capacity for the large generators on their system. On the other hand, testing with D.C. presents no problem. Dielectric tests are made at 125 per cent of the rated phase-to-phase machine voltages, multiplied by 1·41. For 11,400 volts machines; tests are made at 20 KV. D.C. for 5 minutes.

Prior to the application of the high potential test voltage, dielectric absorption tests are made on the stator windings at 1,000 and 5,000 volts D.C. for 10 minutes. The values of insulation resistance obtained by these tests are a measure of the ability of the windings to withstand the dielectric test voltage. In addition, the insulation resistance at 5,000 volts must be not less than 75 per cent of the 1,000 volt value, the 5 minute values being used for comparison. A ratio of less than 75 per cent indicates the presence of moisture and the need for steps being taken to dry out the windings before proceeding with the high potential test. They recommend D.C. dielectric tests.

5. *Swedish State Power Board.*—D.C. testing is employed.

6. *E.E. Co.'s Practice.*—The company has performed some high voltage tests with A.C. on new generator insulation in the works and are at present changing over to D.C. tests. They intend to use a ratio of DC/AC. RMS. of 1·5. One of the American manufacturers has standardised on a factor of 1·6 for new insulation and 1·04 for insulation in service. The D.C. test voltage for a new 11 KV machine is 34·5 KV or for 11 KV machine in service, 26 KV.

7. *General Electric Company (U.K.).*—For routine testing, the General Electric Company recommended a D.C. voltage of 1·2 times 75 per cent of the A.C. pressure test value laid down in B.S.S. for new machines, to be applied between windings and earth for one minute. For a 11 KV winding, this would be $1{\cdot}2\ (23 \times 0{\cdot}75) = 20{\cdot}7$ KV.

This voltage should not be applied directly but should be increased slowly so that the increase in leakage current may be measured. It may happen that a large increase in current for a small increase in voltage is reached, in which case the test should be stopped, as this is an indication of the approach of the breakdown value.

8. *Westinghouse Electric Corporation, U.S.A.*—During the last two years, the Corporation has had D.C. over-potential tests applied to the stator windings of generators, with a total capacity of 4,000,000 KVA to make sure that the machines have adequate insulation level.

For 13·8 KV machines, the usual D.C. test is 30 KV for one minute. In no case has the test failed to reveal serious cases of insulation weaknesses. In addition to stator insulation faults, other incipient weaknesses have been detected in buswork and cables.

9. *The Pacific Gas and Electric Company, California.*—The Company have tested about 3,500,000 KVA of rotating apparatus with D.C. and their predictions of the condition of the insulation are reported to have been 100 per cent correct. The review includes maintenance tests as well as tests on machines undergoing re-conditioning and dry out after bad weather conditions, that flooded or partially flooded some of their hydro plants.

10. *France.*—Engineers in France consider that periodic testing of insulation is often useful. Such tests help to bring to light precise information as to ageing in service of the insulating materials. They however consider that such tests should be limited to those which are non-destructive.

A proposal for conducting routine high voltage test on the generators in service in the Department generally on the above lines is under examination by the Department.

The Indian Electricity Act

Some Desirable Modifications.

K. V. KARANTHA, M.A., M.I.E.,
Chief Electrical Inspector to Government.

I. The Problem of Resale of Electricity Purchased from Licensees.

The existing Indian Electricity Act stipulates that no one shall engage in the "business" of electricity supply, unless he be a licensee or a sanctionee under section 28 of the Indian Electricity Act. The Act does not, however, define as to what is "engaging in the business" of electric supply and that has led to a good deal of controversy over its interpretation. We have, generally, two types of cases of electricity supply by non-licensees and non-sanctionees.

We have the case of isolated generators of electricity, some large temples, cinemas, tea estates, etc., having their own generating sets, because public supply has not come to the place yet, and supplying electricity to a few shops, choultries and houses nearby, at the request of these. There seems to be no

point in wanting to take powers to control them to ensure that the rates of supply in such cases are reasonable or there is efficiency of supply and continuity and no great fluctuations in voltage or frequency, etc. Those who generate energy mainly for themselves can give others no better supply than what they themselves are having and those who ask for supply from them should be content to get whatever they can, instead of insisting on a first-class supply. So, whether they are engaged in the business of electricity supply and therefore should be controlled or debarred from such work is not worth going into. Also such cases hardly ever come up as disputes to the Government.

The trouble comes up almost entirely from another class of suppliers of energy, namely, *consumers* who resell energy, after purchasing the same from licensees or Government. In many such cases licensees have insisted on bringing up such cases as disputes, for the consumers being debarred from doing so. Cases of this type come up under the following four classes :—

(1) The owner of a house takes supply and then in turn supplies energy to a number of other houses owned by him but let-out to others, all contained within the same compound or in adjoining compounds, and without crossing a public street.

(2) An owner takes supply to a big building where there are various types of load, under a composite tariff, such as, "All Electric Home Tariff" and then gives such supply to shops contained within the building, these having only lights and fans.

(3) A consumer takes H.T. supply for a very large building having pumps, lifts, air conditionors, etc., but in which the many flats are let out to a number of tenants, none of whom, by himself, would be entitled to an H.T. tariff.

(4) A consumer takes supply, say, for a textile mill or to a railway colony and then, while using the bulk of it for factory, workshops, offices, yards and godowns, supplies also electricity to his staff having quarters adjoining these workshops and charges for the supply, generally a low rate.

All such cases are common, particularly in large towns, and lead to difficulties to the licensee in framing his tariff or conditions of supply. Two types of difficulties are experienced by him in such cases. He may either have the consumer purchasing electricity at a low rate because of his very large off-take and diversity of demand and then selling it to each of his tenants at the usual rate applicable for their smaller off-takes and thus making a substantial profit on his resale; or the consumer may be making no profit but his staff will be getting electricity for other than the main declared purpose for which the licensee's supply was given and at rates substantially lower than what other consumers of the licensee or even the licensee's own staff may be entitled to get.

One remedy is to have uniform rate per unit for both small and large supplies. But there are

excellent reasons why the larger off-takes should be normally charged at lower rates, such as, the lower cost of delivery in such cases, the relatively lower overhead charges for larger bulks, etc. Also, such lower rates for larger off-takes are desirable as promoting greater sale of electricity. But it is doubtful whether the steep fall in rates for larger off-takes, as now found in many tariffs, is either desirable from the view point of the consumers or for promoting the sale of electricity, or technically sound from the view point of licensee's economic cost of supply.

High initial rates and low follow on rates do not seem to be justifiable from the view point of the general public, since it is the many smaller and poorer consumers that have to be helped whenever feasible, rather than the rich big consumers. Also our future load building in the domestic supply field will have to be, to a very great extent, by reaching down to the lower and still lower economic groups.

We shall next consider the matter briefly from the view point of cost of supply. The case is best illustrated in the example of H.T. supply for commercial buildings. Of course high tension supply has to be obviously cheaper than a low tension supply due to absence of licensee's transformer and L.T. network. But it is doubtful if the large disparity that generally exists in the lighting tariff between a small, mainly lighting, L.T. supply and a large, mainly lighting, H.T. supply is justifiable. The rates for supply to mainly fans and lights are generally about two to three times that for L.T. power and this is justified as being due to the better load factor of the latter. If this were so, the over-all rate per unit for an H.T. supply, used mainly for lighting and fan load in a large commercial building should also be two or three times that for an H.T. industrial load. But this is hardly ever so. The difference is generally far less due to an unduly low rate for the maximum demand charges. For example, in Madras, the overall maximum rate for a general commercial large scale H.T. consumer is only 0·75 anna against 0·66 anna for an industrial consumer. Such low H.T. tariffs for low load factor demands can only be at the expense of the L.T. consumers and are unfair to them and the unfairness becomes greater when a number of flats share such supply at such cheap rates.

Since, even with some improvements to tariffs, substantial differences in rates between large off-takes and small off-takes will continue to exist, we have to see how we can arrange for a consumer not depriving a licensee of the share of the higher rates which should normally go to him for consumption by the tenants. As per the existing provisions of the Indian Electricity Act the only way the licensee could try to overcome the defect was to charge the consumer with "engaging in the business" of supplying electricity without a licence or a sanction, and to bring up the matter as a dispute under the Indian Electricity Act. Many disputes of this type have come up before. But the trend of the decisions

has been that when the owner of a building sells energy to his tenants who are within the same building or compound, it does not amount to "engaging in the business" of supplying energy. The main argument is that the owner of the building is essentially engaged only in renting out his premises and his main source of profit is not from the electricity supply and that the sale of electricity by him is purely an incidental factor. Also, some of the profits he may make in supplying electricity are required to cover his own distribution work. As such this line of contention has not helped licensees.

All the same, the fact exists that in many such cases the owner may make a profit by his resale, which can be out of all proportion to his just dues for reselling electricity or his outlay for the same. Nor would it justify the licensee withdrawing his promotional tariff since many individual large consumers ought to have the benefit of the same. So the point for consideration is as to how the misuse of a promotional tariff by resale by a landlord can be statutorily prevented, irrespective of whether we call it "engaging in the business" of electric supply or otherwise. The present occasion of the revision of the Indian Electricity Act by the Central Government, is the proper time for including the necessary safeguards, to prevent such abuse.

We have been so far considering mainly cases where a profit is made on resale. Any statutory provision we may propose should however also take into consideration the cases where supply taken essentially for factory, workshop and offices is utilised for resale to staff at low rates. The licensee is entitled to expect a reasonable return on his investment from *all* the electricity consumers in his licence area. There are suitable controls over him, as a public utility organisation, to ensure that he makes no more than reasonable profits. If therefore his electricity for domestic purposes for some 99 per cent of his consumers cannot be cheaper than, say, 4 annas per unit, it would seem most unfair to them that a few others—say 1 per cent of the total consumers in his area —living in a cement or textile mill colony or a railway colony, can alone have it at 1 anna per unit or so. It seems to be wrong to supply electricity for a textile mill or for railway purposes for being used also for private purposes. So any statutory provision proposed should cover this type of wrong supplies also.

So it is now for all those engaged in public supply of electricity, to suggest suitable remedies. The best of them could then be included in the new draft of the Indian Electricity Act. Here is one suggestion, to start off.

A provision should be made in the new draft of the Indian Electricity Act to the effect that where a consumer purchases electricity *not only* for use in the premises *occupied* by him, but also in premises *rented* out by him to others, he shall charge for the electric supply to these rented out premises only at the tariffs of the licensee applicable to such individual supplies. He shall also pay to the licensee the excess sums thus collected. Out of this he could keep for himself, say, 10 per cent or 15 per cent for his work of retailing

the electricity to the tenants, metering them individually, collecting the money, etc. A penal provision could be added that where it is found that an L.T. consumer has not disclosed his resales and has not properly accounted to the licensee for the additional sums collected by him, the lower tariff applicable to his total off-take should get automatically cancelled for twelve months prior to the date of such disclosure. For resale at L.T. from H.T. supplies, the computed L.T. resale charges less 25 per cent could be levied.

This suggestion is apart from effecting a partial remedy lying in the hands of the licensee himself by way of re-examining his tariffs, reducing his rates for small off-takes and increasing his rates for large off-takes, where they greatly differ, and substantially increasing the H.T. tariffs for *general purposes* such as for commercial houses. The remedy, no doubt, seems drastic and if something simpler could be suggested it may be done.

II. Ownership of Service Lines.

In the existing Indian Electricity Act, the consumer is expected to pay for that portion of the service line which lies along and up to 100 feet on public road, from the terminal post of the distribution mains of the licensee. The responsibility for the maintenance and renewal of the portion of the service line paid for by the consumer (referred to hereafter as the "consumer's portion of the service line") is, however, specially laid on the licensee. It is not however specified anywhere in the Act that the licensee becomes also the owner of this service line. Based upon trends in some of the other sections of the Indian Electricity Act, legal opinions have been given, both in favour of the construction that the ownership vests in the licensee and also in favour of the opinion that the ownership does not vest with the licensee but vests with the consumer only. In the revision of the Indian Electricity Act, which has now been taken up, it is very advisable that the position is clarified by specific provisions.

To this end, one suggestion that has been made is to limit the portion of the service line to be paid for by the consumer to whatever lies only on his own premises and for all the rest of it to make the licensee bear the expenditure (but on the basis of a minimum annual return of 15 per cent of the capital cost there-of). The portion of the service line on consumer's property being then not large, it is further proposed to vest the ownership of the entire line with the licensee only. There are however certain objections to this arrangement.

It seems to go against ordinary notions of justice or commonsense that the person, who pays for a property, is to be deprived of the right of the ownership of the same. (This aspect, however, is only of importance where a consumer stops taking supply after a few years and the service line is not required. This does not happen in most cases.) The licensee, no doubt, has to be entrusted with the work of maintenance of the service line, being the

only person competent to do it. But then, he can be paid for such service without being made the owner of it also. Even as it is, the licensee invariably charges the consumer for this maintenance work, by treating the cost of such maintenance or replacements as an item of revenue expenditure recoverable from the electricity rates.

Then again, if the ownership of the consumer's portion of the service line is vested in the licensee, then when the undertaking has to be taken over by the Government, or by an Electricity Board, on the expiry of a licence period, the licensee has to be paid for this asset in the same way as for his other assets or works and so the purchaser's investment gets larger than necessary and becomes a permanent burden on the consumers, while the licensee walks away with some extra money for an asset for which he never incurred any capital expenditure.

There is still another aspect to be considered. Where the consumer is a tenant in a house for which the landlord would not agree to arrange for electricity supply and so he had to bear the burden of the cost of the service line himself, it often happens that he wants the supply for only a few years. If after that he is to vacate the premises, it would be hard on him if he were to get nothing for the service connection he had paid for, while if the service line continues to serve at the premises the very unhelpful landlord gets the benefit of it for nothing.

From all these aspects of the question, it seems to be advisable to provide in the new draft for the Indian Electricity Act, the following provisions, as being most reasonable from all aspects :—

(1) The licensee should put up all service lines up to consumer's premises at his own cost. This is to be done on the minimum guarantee basis.

(2) The consumer is to pay for the portion of the service line lying entirely on his own premises.

(3) The licensee should maintain the entire service line and is also to make replacements of the same when necessary.

(4) The cost of the consumer's portion of the service line, however, is not to be included in the cost of his capital assets for earning the "reasonable return."

(5) The licensee should be allowed from his revenues as an item of revenue expenditure, the annual depreciation allowance on the cost of the consumer's portion of the service lines. He should maintain a separate account for this depreciation fund. He should charge to it all costs of replacements of the consumer's portion of the service lines.

(6) The licensee should be allowed to charge to revenue expenditure all other maintenance costs of the consumer's portion of the service line.

(7) When the licensee sells his undertaking, he shall be paid for all his other works, but not for the consumer's portion of the service lines, since he did not invest any money for the same-

He shall also hand over to the successor the balance amount in the special depreciation fund of the consumer's portion of service lines.

(8) If any consumer wants a permanent disconnection, the licensee should pay him 50 per cent of the cost originally collected from him for his portion of the service line.

Regarding item (7) above, it may be explained that at present the practice is to build up a depreciation fund for the consumer's portion of the service line as provided for in the Electricity Supply Act, 1949, and to also charge to revenue all repairs and replacements costs. This is a double burden on consumers. Then again, the depreciation fund, therefore, goes on growing and the licensee then invests the fund in new works and then starts getting a "reasonable return" on the same also. Also, when his licence expires he gets a payment for such works though these works were never built with his own money. It is, therefore, obvious that either no depreciation fund should be built up, but all replacements should be charged to revenue or all replacements should be only charged to this special service line depreciation reserve, and the balance of the fund handed over to the successor to the licensee when the licence expires.

III. Control of Licensees.

In the future set up, when the State Governments will be generating electricity on a very large scale for the use of the public, it is a matter of great importance that in all licensees' areas, there is no check on development due to negligence, inefficiency, mismanagement, corruption or wanton prejudices of licensees (Of course, Governments always go on the assumption that they are free from these defects!) It is likely that in the long period of working of any licensee, in some cases, here and there at least, there will be some cases of this type.

The Indian Electricity Act provides for punishments of the licensees for breaches of the provisions of the Indian Electricity Act. The punishments in the existing Act are most often fines which, however, are paid by the licensee company as an item of revenue expenditure and so it is finally the *consumer that bears the punishment!* Obviously there is therefore scope to improve the Sixth Schedule of the Electricity (Supply) Act by providing for such expenses being excluded from the legitimate revenue expenses of the licensee. Only then would this be a proper way of controlling the licensees for wrong acts.

There are also generally some provisions in the licences which specifically prescribe that for the breach of these, the licence may be cancelled. This act of cancellation of licence is however such a drastic punishment that it cannot most often be resorted to and so is ineffective.

The Electricity (Supply) Act provides for Rating Committees being appointed for fixing revised rates of a licensee and where

a committee is satisfied that the licensee has not been operating with proper efficiency, the rates may be fixed as not to bring in the fair return. But what may happen in such cases is that a licensee will get even more financially crippled due to insufficient profits and then the consumers and the shareholders may suffer even more and there is no guarantee that a management, which has been irresponsible, will be compelled to behave better.

The greatest defect of the existing Indian Electricity Act has therefore been the fact that it has not prescribed a punishment, which is less drastic than cancellation of licence, but more drastic than a mere fine, which in the case of large undertakings, hardly affects the licensees at all.

A suggestion has been made that where there has been a break down of proper management, the Government should have the right to step in and take over the undertaking for running it for a time. This definitely seems to be a useful provision. Another useful provision would be to empower the Government to put any needed extension of works at the cost of the licensee, where he continuously neglects to do so and to treat the money spent for the extensions as a loan given to the licensee on conditions to be prescribed by the Government. In the case of bulk supplies by the Government Electricity Departments, where the dues for the supply mount up substantially due to mismanagement in the licensee's undertaking, there is provision for the Government taking over the undertaking under the Revenue Recovery Act. The Government then can run the show until the dues are realised. It may be worthwhile providing for such powers to the State Electricity Boards also for utilisation on similar occasions.

The great advantage of the Government having powers to take over an undertaking in which there has been mismanagement, etc., is that it gives a chance to the Government to run the undertaking efficiently and to thus prove *beyond all questions of doubt* that the licensee's expenses could have been less and the service to the public better etc.

As to when such a drastic step should be taken, it has been suggested, should be left to the State Government to decide. To make a popular Government the sole judge of such a contingency which may terribly affect the future name of an electric supply undertaking, or of its managing agents, in the financial market, seems however to be rather undesirable. In a matter which affects an electric supply undertaking on a far less substantial matter, namely, the revision of its rates for electric supply, the Electricity (Supply) Act deems it but fair to provide for a competent Rating Committee being appointed to go thoroughly into the matter. The Rating Committee has to be presided over by a judicial officer of not below the rank of District Judge and the findings of the Rating Committee are to be published in the State *Gazette*. Fo the more drastic step of t aking ove

of a licensee undertaking also, a prior thorough examination by a competent impartial committee like this, would therefore seem to be indicated with even greater justification.

As such, it is suggested that provision may be made in the new draft of the Indian Electricity Act for a special Advisory Committee being appointed in all cases where Government consider the drastic action of cancellation of a licence or compulsory modification in the same or the temporary taking over of the undertaking, is indicated. And provision can also be there for the Government to accept the recommendations of the committee or to impose a lesser punishment but not a greater one than suggested by the committee.

In the case of an investigation of this type, the committee should be empowered to report on (1) the extent of evils, inefficiencies, laxities, etc., found in the undertaking, (2) to decide as to whether they are of such a major nature that a cancellation of the licence is the remedy or (3) to suggest that the State Government may take over for a certain number of years and (4) in the latter case to what extent the State Government could give financial loans to the undertaking for putting the undertaking into a better shape and for expanding the same to make it a proper economic unit, etc.

Where the Advisory Committee agrees that drastic action by Government is necessary, the report of the committee should be published in a gazette so that all the consumers and the shareholders of the company may also be made aware of its findings. The need for making the report available to the share-holders is very great since in most cases they are unaware of the real situation. The share-holders should thus be given a chance to review the position for the purpose of making alterations in the management or terminating the services of the existing managing agents, etc.

Based on a report of the Advisory Committee that there has been substantial mismanagement necessitating drastic action by the Government, the Government should firstly call upon the licensee to amalgamate with any of the other licensee undertakings in the State, to ensure improvement of efficiency or as a means of improving the financial position for future working, etc. The licensee may be given six months time for the purpose. Where however the licensee does not arrange for such amalgamation in a form that meets the Government's approval, the Government should arrange to either cancel the licence or if take over licensee agrees, the same for the period specified by the Advisory Committee.

When the Government runs the undertaking, it may either result in a loss or in a profit. Inherently it would be wrong to pass on any loss incurred to the licensee. That is because the Electricity (Supply) Act empowers an undertaking, so long as it is working efficiently, to so adjust its rates that it can earn a reasonable return. Since therefore the Government will have the means to adjust its rates, it may look illogical for the Government to tell the licensee that loss

has been incurred. The best thing is to provide for the running of the undertaking for such a period that it will, taking the whole period as such, end in no loss, but if possible also in earning some profit for passing on to the licensee.

During the period of working by the Government, it should be made necessary that any Managing Agents who were running the undertaking till then, become statutorily ineligible for claiming any managing agency allowance or commission, until the undertaking is handed back to the licensee. On the other hand, the charges which the Government, would levy for management in such cases should also be only within certain limits to be prescribed by the I.E. Rules generally.

Where the findings of the Advisory Committee clearly showed that the managing agents were mainly responsible for the mismanagement, there should also be a statutory provision for giving a chance to the share-holders to either continue the services of the old managing agents or to arrange for a new management or *for requesting the Government to continue to manage the undertaking*, even after the "punishment" period of management by the Goverment, is over.

Most often it will be necessary for the Government to advance loans to the undertaking, when working under its control. There will be very many defects to be rectified which will mean money. It is also obligatory on a licensee to cater to new load. There should therefore be provision for the Government to put up new works, etc. (Where an undertaking has been taken over under the Revenue Recovery Act, there is no such provision for expansion which is a great handicap to prospective consumers). In the case of an undertaking which however is inherently unremunerative due to the poor resources of the area, etc., it should not be feasible for the Government to put in so much money that the mortgage rights on the same will reduce the investments of the ordinary shareholders to nothing. It is advisable that the loans invested by the Government together with any other loans already due by the undertaking be not over 50 per cent of the share-capital of the undertaking. The payment of the Government loans should be spread over a long period, probably the entire balance life of the licensee, so that the undertaking will not be throttled by having to find money for heavy repayments every year.

Where a licensee has not yet started supply, but the undertaking has shown gross mismanagement and delay and breach of many licence terms, the cancellation of a licence is not a very serious matter. But where supply has continued for some time, there should be no provision for the assets being sold away piece-meal when a licence gets cancelled. In the interest of the public who have been taking supply, it seems to be advisable to make it obligatory on the State Government or the State Electricity Board to take over all *such undertakings*.

The local authority, as a licensee, is comparatively very efficient. But it does not form a logical unit for electricity supply over a composite area. It is advisable that where a licence is cancelled, there is therefore no provision for the local authority having any choice for taking over of the undertaking, unlike in the present Act.

Where a licensee has been found to be unreasonably tardy in the putting up of any extension of supply lines, etc., the Act should give power to the Government to put up the necessary extensions at the cost of the licensee and the money being recovered in a prescribed manner.

In the matter of the inefficiency of a licensee, it often happens that the symptoms of the same appear far earlier in the annual accounts than the final show-down. The Indian Electricity Act, as it stands now, while necessitating the licensee maintaining and submitting accounts, nowhere specifies that it is also obligatory on the licensee to carry out the instructions of the Government issued when reviewing such accounts. It is obviously necessary to provide for a licensee having to compulsorily carry out the instructions of the Government in such matters. Where a licensee disagrees with the Government's directions, scope can be provided for taking up the matter for arbitration.

Power should also be taken in the revised Act to publish the remarks of the Government auditor and of the Government on the review of the annual accounts, in the State gazette, whenever the Government considers it necessary. The public and the share-holders can thus be appraised of the views of the Government and these views will help substantially to enable share-holders to correct bad trends in the management, or for consumers to insist on better rates or terms of supply.

Due to the unsatisfactory financial working of some electric supply companies, this field of investment by the public, which was considered a semi-gilt edged one some twenty years ago, has lost greatly its attraction for the investor. The provisions for control of electric supply licensees suggested above, which would adversely affect only a few bad licensees, will however, it is believed, substantially help to make this public utility industry a more attractive field for investments in future.

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MADRAS

Madras Power Grid Interconnectors

By G. S. RAMA IYER, B.Sc., M.I.E. (Ind.),
Executive Engineer.

Scope.—Several transmission interconnectors are in operation in the Madras Power Grid, over the last two decades, with the successive advent of the several hydro power stations at Pykara, Mettur, Papanasam and Moyar as well as the thermal power stations at Madras and Samayanallur to firm up the hydro power. The scope and various possibilities of these interconnections in not only co-ordinating the power resources of neighbouring systems but also in the utilization of the power sources in the most economical and rational manner are too well-known to need any description. The technical aspects of certain new problems which would pose themselves ere-long on greater loading of the Grid are discussed in this note.

A complete list of the interconnecting lines operating at present in the Madras Grid is furnished below:—

(1) Coimbatore-Erode 66 KV interconnection lines.

(2) Pykara-Madurai-Papanasam interconnection lines.

(3) Mettur-Singarappet-Villivakkam 110 KV tie line with Madras.

(4) Moyar-Erode interconnection lines with Mettur.

(5) Moyar-Pykara interconnection with Pykara.

(6) Samayanallur-Madurai interconnection with Papanasam.

In the development of the Madras Grid from 1931 to 1953, we come across three aspects of the interconnecting lines, namely, their co-ordinating aspect, their power utilisation aspect and their economic aspect.

The above interconnection lines can either operate individually or in co-ordination with others or in any permutation or combination thereof, dictated by the seasonal operation needs and any deficit or surplus of power in any of the generating stations, or maintenance necessity in any of the stations.

Parallel Interconnection Lines.—Though so far the need for interconnection of power stations was restricted to single route interconnection line only, the operation in parallel of the tie lines that interconnect two points in the Grid but along separate routes, would ere-long become necessary. Some cases of such type as would be of particular interest in the immediate future, are considered below. There are two categories of such parallel interconnectors. Firstly, we have the case of interconnectors running along different routes but operating at the same voltage. An example is interconnectors between the Pykara and Moyar power stations via Erode and also via Coimbatore. Secondly, we have parallel interconnection lines operating at two different voltages

though between same two terminal sub-stations or load centres. In this second category we have the existing 66 KV double circuit lines and the newly erected 110 KV line, between (*a*) Erode and Tiruchirappalli and (*b*) Coimbatore and Madurai in the event of all the three lines being operated in parallel with adequate parallel feeder protection extended to all the three feeders.

Considering the first of the two categories, the problem of parallel operation is more typically stated below for evolving the solution.

As indicated in figure 1, the Pykara station with its 70 Megawatts (after 1954) and Moyar with its 25 Megawatts will be called upon, in emergencies, to meet a demand of say 45 Megawatts at the Erode sub-station. The Moyar-Erode double circuit 110 KV lines with 6/·208 plus 7/·069 a.c.s.r. conductors are designed for a normal loading capacity of 40 Megawatts for 5 per cent regulation over the 72 mile length of double circuit line and 10 per cent line losses for single line operation.

The system loads to be met by Pykara station may comprise—

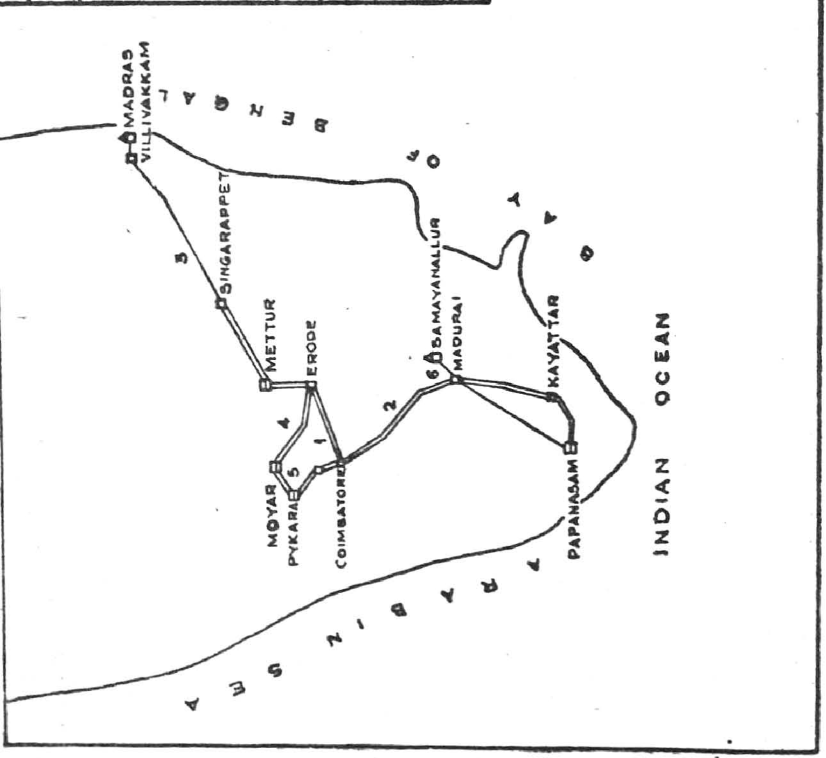
(*a*) 9 Megawatts of 66 KV, 22 KV and 11 KV loads directly off the station buses,

(*b*) 30 Megawatts of 11 and 22 KV loads off the Coimbatore 110 KV bus and,

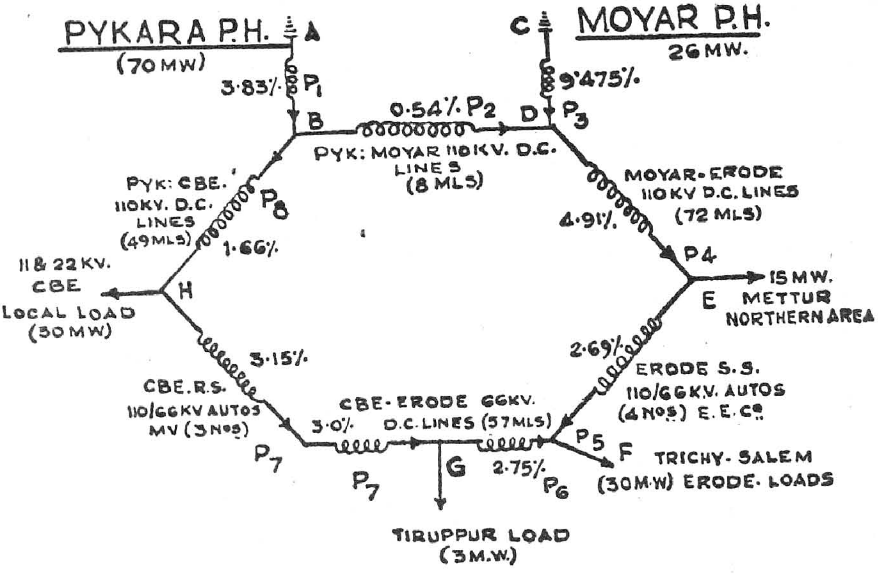
(*c*) 66 KV supply off 3 Nos. Autos at Coimbatore sub-station to meet 3 Megawatts of Tiruppur load. Allowing for the diversity in the peak demand of (*a*), (*b*) and (*c*) the simultaneous peak demand on Pykara station due to its own system loads plus 10 per cent losses is say 45 Megawatts. The Pykara station has therefore 70 Megawatts less 45 Megawatts or 25 Megawatts to spare with all units running. Moyar (with one unit as spare) will have only 25 Megawatts surplus, allowing 1 Megawatt for station auxiliaries and local 11 KV loads. The Erode sub-station demand of 45 Megawatts is therefore to be supplied by 25 MW from Moyar station and the balance of 20 Megawatts from the Pykara station. This 20 Megawatts from the Pykara station can either wholly pass along the Pykara-Moyar-Erode 110 KV double circuit of 80 mile length overloading the Moyar-Erode line. Or part of it can flow along this route and the balance via the Coimbatore Autos and the Coimbatore-Erode double circuit 66 K.V. lines to Erode 66 K.V. bus over a total distance of 49 miles to Coimbatore plus 56 miles to Erode. As the impedances of these two routes are different, the interconnection lines will share the total load in inverse proportion to their impedances. Figure 2 indicates the natural division of the 45 Megawatts load along the two parallel interconnections. As the normal capacity of the Moyar-Erode 110 KV double circuit line is only 40 Megawatts, this is likely to be exceeded by the natural load division if dependent on the impedance values only. But it is suggested that with the provision of quadrature booster transformers either at Coimbatore or Erode, in addition to the onload tap changing arrangement on the Autos, any desired power flow along the Coimbatore-Erode 66 KV double circuit lines can be effected. Thereby not only the over-loading of

GENERATION - 1954 AND AFTER

HYDRO STATIONS	OUT PUT
PYKARA	70 M.W.
METTUR	40 M.W.
PAPANASAM	28 M.W.
MOYAR	36 M.W.
TOTAL.	174 M.W.
THERMAL STATIONS	**OUT PUT**
MADRAS	78 M.W.
SAMAYANALLUR	14.M.W.
TOTAL.	92.M.W.
ALL TOTAL.	266 M.W.



Serial number. (1)	*Interconnector Lines.* (2)	*Voltage.* (3)	*Length in Miles.* (4)	*Conductor Size.* (5)	*Tie-Line Loading Maximum operated so far.* (6)	*Stations Interconnected.* (7)
1	Coimbatore,-Erode D.C.	66 KV.	56	7/·144 A.C.S.R.	20 M.W.	Pykara and Mettur.
2	Coimbatore-Madurai D.C.	66 KV.	120	7/·144 A.C.S.R.	10 M.W.	Pykara and Papanasam.
3	Singarappet-Villivakkam S.C.	110 KV.	123	6/·186+7/·062	15 M.W.	Mettur and Madras.
4	Moyar-Erode D.C.	110 KV.	72	6/·208+7/·069	25 M.W.	Moyar and Mettur.
5	Pykara-Moyar D.C.	110 KV.	8	6/·208+7/·069	15 M.W.	Pykara and Moyar.
6	Samayanallur-Madurai S.C.	33 KV.	6·5	19/·092 Copper.	8 M.W.	Madurai and Papanasam.



'p' IS USED TO REPRESENT POWER FLOW IN MEGAWATTS

POWER FLOW IN INTERCONNECTED PYKARA-MOYAR E.H.T. SYSTEM.

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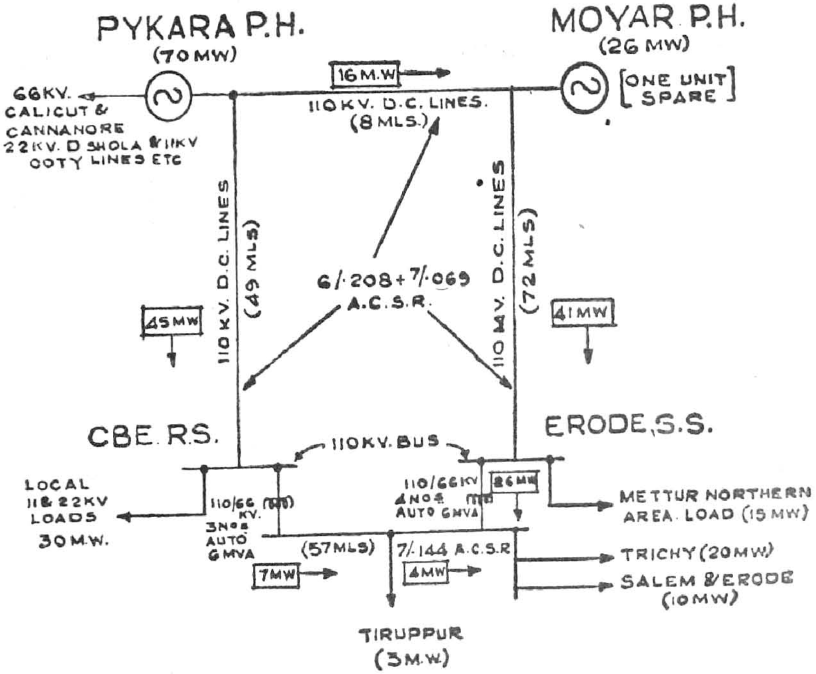
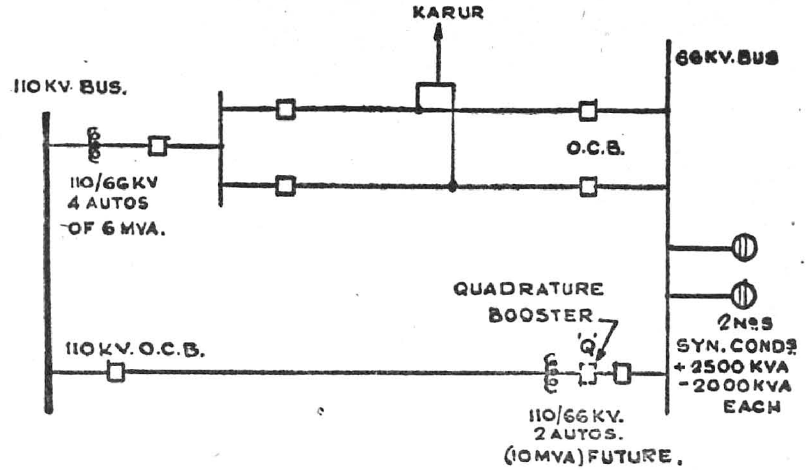


FIG. 2

PYKARA & MOYAR SYSTEMS.

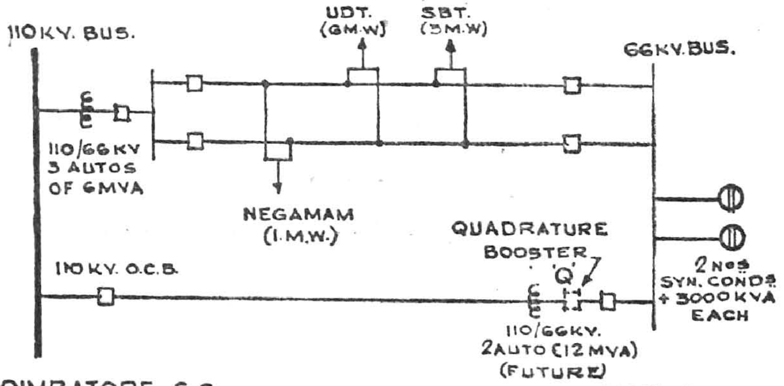


ERODE S.S.

FIG. 3.

TRICHY S.S.

ERODE - TIRUCHIRAPPALLI
PARALLEL - INTERCONNECTORS



COIMBATORE S.S.

MADURAI S.S

FIG. 4.

COIMBATORE - MADURAI
PARALLEL - INTERCONNECTORS

Moyar-Erode lines can be avoided but also the surplus power at the Pykara station can be fully and economically utilised during such emergencies as low water conditions at Mettur, when its power generation is too inadequate to meet its system loads or Mettur generators are to be only run as synchronous condensers to help regulation if no generation is possible.

Similarly in the two instances of the second category of interconnection lines the natural load division along the double circuit 66 KV lines as against the 110 KV single circuit line in parallel may be a sharing of loads as dictated by the impedance values, but if it is desired to draw much greater power along the single-circuit 110 KV line up to its maximum permissible loading we should have at the receiving end of the 110 KV single circuit line, the quadrature boosting transformers.

While it may be argued that independent operation of 66 KV and 110 KV lines may be more practicable and less complicated from the aspect of parallel three feeder protection we cannot possibly ignore the advantages that will accrue by adopting the arrangement suggested above, namely :—

(*a*) the utilization of the corrective equipments like the synchronous condensers at Tiruchirappalli and Madurai for regulation purposes for the entire receiving end bus, which is not feasible with split bus operation ;

(*b*) the full utilisation of the loading capacity of all the three feeders and Autos at the station ends with optimum power losses on each of the lines, and the better reliability of power supply to loads at and beyond Tiruchirappalli and Madurai, respectively.

Referring to the figures 1 *and* 2 (*as per Thevenin's Theorem*) *with link BD open, the Power flow will be :—*

$P_3 = P_4 = 25$; $P_5 + 15 = P_4 \quad \therefore P_5 = 10.$
$P_6 + P_5 = 30 \quad \therefore P_6 = 30 - 10 = 20.$
$P_7 = 3 + P_6 \quad \therefore P_7 = 20 + 3 = 23.$
$P_8 = 30 + P_7 \quad \therefore P_8 = 30 + 23 = 53.$

The product (percentage Reactance $\times$ Megawatts) for flow between B & D.

$= 1{\cdot}66 \times 53 + (3{\cdot}15 + 3{\cdot}0)\ 23 + 2{\cdot}75 \times 20 - 2{\cdot}69 \times 10 - 4{\cdot}91 \times 25.$
$= 84{\cdot}66 + 141{\cdot}45 + 55 - 26{\cdot}9 - 122{\cdot}75.$
$= 131{\cdot}46.$

Therefore percentage Impedance of network between B and D

$$= \frac{18{\cdot}16 \times 13{\cdot}305}{18{\cdot}16 + 13{\cdot}305} = \frac{241{\cdot}569}{31{\cdot}465} = 7{\cdot}68 \text{ per cent.}$$

$$\text{Power flow in the link BD} = P2 = \frac{131{\cdot}46}{7{\cdot}68 + 0{\cdot}54} = \frac{131{\cdot}46}{8{\cdot}22} = \underline{16 \text{ M.W.}}$$

Natural Power flow in the net work—

P_2—Pykara Moyar 110 KV D.C. line	16 M.W. towards Erode.
P_4—Moyar—Erode 110 KV D.C. line	25 M.W. plus 16 M.W. or 41 M.W. to Erode.
P_5—Through Erode 110/66 KV Autos.	41 M.W. less 15 M.W. of Relief to Mettur or 26 M.W. (10 per cent over-load on Autos).
P_6—Tiruppur-Erode 66 KV D.C. line.	30 M.W. less 26 M.W. or 4 M.W. (feed from Pykara to Erode.)
P_7—Coimbatore-Tiruppur 66 KV D.C. line or power flow through Coimbatore Autos 110/66 KV.	3 M.W. of Tiruppur load plus 4 M.W. supply to Erode or 7 M.W. of Pykara supply.
P_8—Pykara-Coimbatore 110 KV D.C. line.	30 M.W. of Coimbatore local loads plus 7 M.Ws. through Coimbatore Autos or 37 M.Ws.

NOTE.—Pykara Generation of 70 M.Ws. meets—

(a) 9 M.Ws. of Calicut-Cannanore 66 KV loads, 11 and 22 KV loads directly off Pykara bus.

(b) 37 M.Ws. off Pykara-Coimbatore line.

(c) 16 M.Ws. off Pykara-Moyar plus line losses about 10 per cent of the loads.

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MADRAS

Expansion of the First Five-Year Plan

[With special reference to Madras State Plan after partition of the State.]

By P. RAMAMURTHI, B.E.
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The First Five-Year Plan had always been considered by the Planning Commission as flexible and capable of being modified to suit changing needs during the currency of the Plan itself. In its first two and a half years of execution, the economic setting in India has considerably changed, the change itself being, at least partly, if not wholly, the result of the benefits of the Plan that are gradually materialising. Food production has increased and the crop prospects in the current year have removed fears of any shortage. The price situation has been stabilised and the inflationary forces have been successfully held. A new problem of urban unemployment has come to the forefront in the recent months. It may be recalled that the House of the People adopted a resolution on 18th December 1953 calling for a revision of the First Five-Year Plan with a view to increasing employment opportunities in the country. Those responsible for planning considered that the progress of the Plan had to be reviewed under the altered economic conditions and strengthened wherever necessary to relieve the stress of unemployment.

It will be interesting at this stage to compare the progress of expenditure during the three years, 1951–52, 1952–53 and 1953–54, with the targetted expenditure for the five-year period.

Year.	*Expenditure in the Centre and States (in Rs. crores).*
1951–52	261·5
1952–53	323·5
1953–54 (R.E.)	413·0
Total for 3 years (1951–54) ..	998·0
Total plan provision for 5 years 1951–56 ..	2,069

It will be seen that over the three years or 60 per cent of the total five-year period, the expenditure is less than 50 per cent of the Plan, provision for which, as the reader may see later, has been further expanded. The expenditure in the last two years of the

Plan has therefore to be stepped up considerably if the Plan is to be implemented in full.

The National Development Council which includes all the Chief Ministers of States reviewed the progress of the Plan in October 1952 and agreed to the addition of projects to the Plan entailing an additional expenditure of Rs. 150 to Rs. 175 crores during the period of the present Plan. The conditions laid down for addition of such new schemes are—

(1) they should be strictly related to the provision of additional employment;

(2) they should be such as to produce results within the period of the Plan, i.e., they should not be long-term projects;

(3) training and other programmes should be related to the needs of the Plan and should be confined to those sectors in which there were shortages.

Broad categories of schemes which will be taken up under the expansion of the Plan were also decided upon by the National Development Council as follows:—

	In Rs. crores.
(1) Additions in the programmes of the Central Ministry ..	70
(2) Programme of permanent improvement in scarcity areas.	40
(3) Additions in the programme of State Governments ..	25
(4) New programmes for increasing employment especially in urban areas.	15 to 40
Total ..	150 to 175

The additional programmes of the Central Ministry cover several fields, viz., rehabilitation of displaced persons, road development, construction of office and residential buildings, health schemes, agricultural schemes, etc.

The second item, viz., programmes of permanent improvement in scarcity areas is intended to benefit those areas in several States which are chronically affected by scarcity conditions and in which "because of low purchasing power and repeated interruptions to economic activities, relief works and other measures are needed from time to time." These schemes will be financed by loans from the Central Government repayable over a period of 30 years which will be interest-free for the first five years.

The third item consists of:—

Field of development.	*Allotment (in Rs. crores).*
Power	9·1
Roads and road transport.	8·1
Irrigation	3·5
Housing	1·5
Social services	1·8
Industry and technical training.	1·1
Total ..	25·0

The last item, viz., programme for relief of urban employment will be broadly of the following categories :—

(1) assistance in setting up State Financial Corporation for small scale and cottage industries (over and above the provision in the plan) ;

(2) provision of additional thermal plants in urban areas ;

(3) loans for housing programmes for low income municipal and Government employees and for co-operative housing ;

(4) financial assistance for the assistance of road transport service ;

(5) work and training camps, apprenticeship and reorientation courses ; and

(6) implementation of the recommendations of the standing educational commission relating to the diversification of courses, introduction of crafts, improvements of teaching of science, etc.

While the plans of the Centre and all States were therefore expanded on the above lines, the Madras State Plan had further to be revised due to the partition of the State on 1st October 1953. The economic significance of partition can easily be understood from the fact that while the new Andhra State has got an area of 63,417 sq. miles and a population of 20,507,801, Madras has a population of 35,734,489 and an area of only 60,189 sq. miles. The density of population in Andhra is 323 per sq. mile while in Madras it is 594. The Plan of the composite Madras State was broken into the respective components after the partition and the part relating to the new Madras State was then revised and brought up to date. The revised plan envisages an outlay of Rs. 92 crores in the five-year period 1951–56 against Rs. 137 crores of the composite State. The emphasis of the Plan is still on irrigation and power with an outlay of Rs. 49 crores (Rs. 21 crores for irrigation and Rs. 28 crores for power). Particulars of the revised Plan are as follows. The original composite State figures are also given for comparison.

Field of development.	*Provison under revised plan for new Madras State.*		*Old provision for composite State.*	
	Amount (in Rs. crores).	*Percentage of total.*	*Amount (in Rs. crores).*	*Percentage of total.*
1. Agriculture	18·75	20·4	21·90	16·0
2. (*a*) Irrigation	20·85	22·6	30·17	22·0
(*b*) Power	28·31	30·8	50·24	36·7
3. Transport and communication.	3·58	3·9	2·12	1·6
4. Industry	1·85	2·0	5·00	3·6
5. Social services	18·74	20·3	27·59	20·1
Total ..	92·08	100	137·02	100

The progress of expenditure of the Madras State Plan under the several fields of development for the three years 1951–54 and the budget estimate for 1954–55 are given below :—

Field of development.	*Revised plan for 5 years* 1951–56	*Expenditure in the 3 years* 1951–54	*Balance for the 2 years* 1954–56.	*Provision in the budget estimate for* 1954–55.
	RS.	RS.	RS.	RS.
1. Agricultural and Rural development.	18·75	7·01	11·74	4·40
2. (*a*) Irrigation	20·85	11·18	9·67	5·14
(*b*) Power	28·31	14·46	13·85	4·96
3. Transport	3·58	2·22	1·36	0·54
4. Industries	1·85	1·34	0·51	0·15
5. Social services	18·74	8·90	9·84	3·27
	92·08	45·11	46·97	18·46

It may be mentioned here that the Irrigation and Power Schemes in the revised plan now include four new irrigation schemes and one power scheme approved by Planning Commission as under :—

Name of scheme.	*Total estimated cost.*	*Benefit in acres irrigated or MW installed generating plant.*
Irrigation Projects.		
1. Amaravathi reservoir	Rs. 272 lakhs.	15,000 acres.
2. Vaigai reservoir	About Rs. 200 lakhs.	Exact scope still not defined.
3. Krishnagiri	Rs. 184 lakhs.	7,500 acres.
4. Sathanur	Rs. 263 lakhs.	20,000 acres.
Power Projects.		
1. Periyar Hydro-Electric Scheme.	Rs. 1,048 lakhs.	75 MW. initial & 100 MW. ultimate.

The four irrigation schemes above approved by the Planning Commission are understood to come under the category of programmes for permanent improvement in scarcity areas referred to earlier and they will therefore be eligible for the Central Government loan. In addition to the Periyar Hydro-electric Scheme, another hydro-electric scheme, viz. Kundah Hydro-electric Project at a cost of Rs. 26·0 crores initial and Rs. 35·4 crores in 10 years bringing 145 MW generating capacity in the initial stage and 180 MW in the second stage was recommended for inclusion in the first five-year plan and it is still awaiting approval of the Planning Commission. It is hoped that their approval will be received shortly and the Government of Madras will be able to commence the scheme in the first five-year plan itself.

There are already press reports about the second five-year plan. It is said that a Rs. 7,000 crore plan is being contemplated for the second five year which would mean that the scale of expenditure will be more than thrice the first five-year plan. It is also but right that even as the first plan is coming to close, thoughts should be given to the scope and size of the second plan so that the transition is smooth and co-ordinated advance in all fields is ensured. The Minister for Planning at the Céntre has remarked in this connection that herculean efforts are necessary in the next two years so that capital formation could be made at high level to launch the second five-year plan with bigger targets.

As far as the Madras State second five-year power plan is concerned it is now more or less certain that besides continuing Madras Plant Extension III stage thermal scheme, the Periyar and Kundah–Hydro-electric schemes, a new scheme, viz., the lignite thermal scheme (with 100 MW initial and 200 MW ultimate installed capacity) will be taken up. When these schemes materialize by the end of the second five-year plan, installed generating capacity in the State will be raised from 260 MW at the end of the first five-year plan to over 600 MW at the end of the second plan, i.e., it will be more than doubled.

Referring to the scope of these plans, the Deputy Chairman of the Planning Commission, Sri V. T. Krishnamachari is reported to have stated as follows while recently addressing the 46th annual general meeting of the Indian Merchants Chamber at Bombay. "Our effort does not end with the present Plan. Our horizon is much wider that of doubling the *per capita* income as soon as possible". Similarly the Electricity Department of Madras, may well have a target of doubling the present *per capita* consumption in the State in the next 5 years (which is now 15 units after the partition).

Construction and Maintenance Practice with Steel-cored Aluminium Conductors

By E. N. NARAYANASWAMY, B.E.,
Junior Engineer.

In this article a brief outline is given of the erection practice with a.c.s.r. conductors for pole-lines and the problems facing the maintenance engineer in their use.

Long experience has shown that in spite of the widely different properties of the two materials, aluminium and steel, which are contained in the a.c.s.r. conductors, the composite conductor behaves as a homogeneous whole, having physical properties intermediate between those of the components.

Erection practice.—The methods employed in the erection of steel-cored aluminium conductors are almost the same as for copper conductors except that much greater precautions and care have to be exercised in the case of the former against damage.

The general scheme of erection is divided into three parts :—

(1) Paying out the conductors from the drums and hauling them over snatch blocks hung from the cross arms.

(2) Pulling up the conductors, still hanging in the snatch blocks, to the correct tension and adjusting the sag.

(3) Transferring the conductors from the snatch blocks to the pin insulators and binding.

The snatch blocks must be of robust design, and must be so designed that the conductor can readily be disengaged and transferred on to the pin insulators while under tension. The pulleys must be of large diameter and must be very free running. Well designed roller bearings are practically essential if long sections of conductor are to be pulled up at one time.

The clamps used on the conductor during the process of pulling up are usually of the automatic type, simple bolted type made of steel or the bolted type made of wood. These are illustrated in figure 1.

The automatic type has the advantage of quick action and quick release saving much time. Practice has shown that the use of the simple bolted type of clamps, which, though requiring more time to apply or remove, is preferable since this would give a very positive grip which is not liable to fail.

In the automatic type, the jaws are best lined with soft aluminium. In the bolted type the conductor is gripped between blocks of steel lined with aluminium sheet, or blocks of hard wood with

grooves of the correct diameter. In no case should aluminium be gripped directly by steel surfaces.

1. *Paying out.*—The practice obtaining in the Western countries and America is that where the line runs along a road side, the conductor drums are mounted on wagons, which are run along near the poles, the conductor being hauled up to the cross arms as each pole is passed. But this method is not generally practicable in this country. Normally the drums would be mounted on screw jacks or a drum-stand on the ground, and the conductor hauled off by means of a light steel line known usually as the messenger wire. Some form of braking device should be provided to prevent the conductor drums from over-running during hauling and causing the conductor to kink.

2. *Pulling up.*—At the point selected for pulling up, the conductor is carried over the snatch block and brought down to a triple sheave block and tackle, well anchored into the ground and fitted with a dynamometer. Manual power and tackle will be found sufficient to pull up smaller sizes of conductors, but in the case of large a.c.s.r. conductors on long sections, some mechanical power such as, for example, a winch driven off a motor lorry or a petrol engine will be found necessary. By this means the conductor is pulled up steadily until the applied load is substantially more than the tension finally required. The purpose of this extra pull is to "take the stretch out of the conductor" and thus ensure that under working conditions, there would be no slow increase in sag, due to the settling down of the individual wires.

3. *Sagging.*—A sag board of the design shown in the figure 2 is fixed to each of the two adjacent poles at the desired level of lowest point of one conductor. A work man on one pole keeps his line of sight between the two boards and the conductor is then slowly let down until he signals that the correct sag has been reached. Only the lowest conductor need be sagged in this way, the others being then adjusted parallel to this one.

If the snatch blocks are easy running, the sags in all the span lengths pulled up together should equalize automatically, but it may be necessary for the workers to equalise sags if the hanging snatch blocks are seen displaced from the vertical.

An accurate check of the sag of a conductor already erected (not energised) is as follows: The conductor in a span which does not contain a splice is struck with the hand or some suitable instrument, or it may be jerked with a cord thrown over the conductor about 3 feet from the support. A ripple travels over the conductor to the far point of support, is reflected at that point and returns. The time taken by the ripple to travel to the far end and back three (or more) times is measured by a stop watch and recorded.

The sag can be determined from the table given below or if the sag is greater than the values shown,

the formula $D = 0{\cdot}118T^2$ may be used, where D = Sag in feet and T = time in seconds. For satisfactory results the conductor must be hanging still, not disturbed by wind or by linemen working on adjacent poles.

TABLE 1.

Sag Value (Ripple method).

Time in seconds for 3rd beat.	*Sag in inches.*
2	5
3	12
4	22
5	34
6	48

Sag value (Ripple method)—cont.

Time in seconds for 3rd beat.	*Sag in inches.*
7	66
8	86
9	109
10	134

This method can be reliably adopted for measuring the sag on the existing lines. An experiment to examine the correctness of this method was conducted on a representative section of the Coimbatore-Perianaickenpalayam 22 KV double circuit line and the results obtained by three methods for measuring the sag are furnished in the table below :—

Serial number.	*Span length.*	*Sag value.* *Method* (1)	*Method* (2)	*Method* (3)
	FT.	INCH.	INCH.	INCH.
1 ..	300	21	21	22
2 ..	220	21·3	24	Between 22 and 34
3 ..	330	25·7	25	
4 ..	345	28·1	28	

Method 1.—Measuring the tension in the line using a dynamometer and then arriving at the sag value.

2.—Actual measurement of the sag in the line by the use of sag boards.

3.—By ripple method.

The ripple method is very simple and needs no elaborate arrangements for use, but it suffers from the disadvantage that the sag values cannot be measured correct to an inch, as seen from the table.

4. *Clamping and binding.*—The attachment of the strain grippers may be done at the pole top or on the ground. In the latter case the conductor is plainly marked by pencil or a piece of tape, as it lies in the snatch blocks and the tension then slackened off till the conductor comes down to the ground. The gripper-clamp is attached to the correct distance

marked, and the conductor hauled up to the pole-top again by means of a *come-along clamp*, applied at a point one or 2 feet away from the clamp on the line side.

In many cases, especially on a double or triple pole structure, where there is enough space on the top, this work is done at the pole-top itself, in which case, after the conductor has been marked, the tension on the line is slightly increased and the gripper-clamp attached at the correct point and fixed on to the tension disc. The pull on the come-along clamp is now slackened off.

Some types of the strain clamps or the dead-end clamps as they are called generally used for a.c.s.r. conductors are shown in figure 3. The correct size and type for the size of conductor to be used, should be chosen.

In no case should the aluminium conductor be gripped directly by the inner surfaces of the clamps. For this purpose the conductor is provided with a layer of flat aluminium tape in the portion to be clamped in, plus about 3 inches on either side. This also serves as a protection against fatigue due to vibration.

The final stage consists in transferring the conductor from the snatch blocks at the intermediate poles on to the pin insulators and putting on the bindings.

The most usual method for tieing the conductors especially the a.c.s.r. to pin insulators is the 'armour top' tie shown in figure 4.

A type of binding known as 'pig tail' tie, which is popular in America for small sizes of conductors on moderate spans is shown in figure 5. The conductor is first provided with a layer or layers of flat aluminium tape where it lies in the insulator groove. The middle part of a length of binding wire is then applied to the insulator groove and bent upwards on both sides round the conductor, forming one complete turn. The ends are brought round the front of the insulator groove, crossing over one another and given two complete turns round the conductor on each side. The ends are then brought back again round the insulator neck and fastened off by twisting together as shown.

When especially severe windy conditions are anticipated or when the span is long the extra strong type of binding known as 'stirrup tie' shown in figure 6 would be employed. In this, use is made of stirrups of stiff aluminium wire which are obtained pre-formed to the correct shape for the size and type of insulator used. The stirrups are fitted closely round the neck of the insulator and, where they come together, are bent upwards and outward, so as to lay in the same plane as the insulator groove. The conductor is lapped with aluminium tape for a length equal to the length of insulator groove plus 6 inches and laid in the groove so that it is touching the stirrups. One end of the suitable length of binding wire is laid in the underside of groove between the two stirrups and the wire wrapped closely round the conductor and stirrups for 10 to 20 turns, the ends of the wire being fastened together on completion.

This is repeated on the other side of the insulator.

It should always be borne in mind that the correct size and length of the binding wires should be used in the case of a.c.s.r. conductors. Pliers should never be used in the wire bindings, as there is always the risk that they will damage the wire in some way which may eventually lead to trouble. Application of the binding wire is always to be done with fingers and finally the ends should be lightly tapped-down with small hardwood blocks made for the purpose.

Use of parallel groove clamps.—When aluminium or a. c. s. r. conductors are to be jointed in positions where the joint will not be under mechanical load, the simplest form of joint is a two piece casting of pure aluminium, the two parts of which are bolted together gripping the conductor ends in two grooves on each side of the line of bolts. The grooves are accurately made to the exact diameter of the conductor and the length of the clamp is at least six times the diameter of the conductor, so that a larger contact surface is ensured. The efficiency of the joint will be further improved if the clamp grooves are thickly smeared with graphite grease before clamping on the conductors.

A typical form of the clamp generally used is shown in figure 7. The body of the clamp is made of pure aluminium and the bolts are of galvanised steel or of a non-corrosive aluminium alloy.

Mid span joints.—The simplest type of joint designed for taking up the full tension of the line is the McIntyre or Torsion joint, in which the two ends to be jointed are slipped from opposite sides into an oval aluminium tube, known as the torsion sleeve. This sleeve is then gripped at each end by a pair of twisting tongs, by means of which it is given 4½ to 5½ complete twists. The joint is thoroughly reliable, with higher strength and electrical conductivity and it is readily made even by unskilled labour.

These joints are used for a.c.s.r. conductors up to about 0·6 inch diameter. For larger sizes manual twisting becomes very difficult and other means of jointing such as the core joints or the compression joints are adopted.

It is beneficial to apply vaseline or yellow grease to the end of the conductors before inserting them into the sleeve. This tends to improve and preserve the electrical conductivity, especially on the sea coast or similar locations where salt or other fumes may deposit within the joint.

Bimetallic clamp.—It is well known that when a direct contact between aluminium and copper is exposed to moisture, electrolytic action occurs, leading to the rapid corrosion of the joint. The presence of moisture is essential for this action to occur and all danger is removed if means are provided to keep the joint dry. A liberal coasting of bituminous paint is a sufficient protection against moistures, and many types of clamp designed depend for their efficient functioning upon such painting. It is desirable however, that the clamp

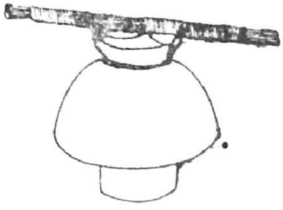


FIG. II
"ARMOUR TOP" PIN BINDING

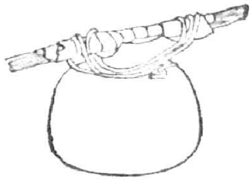


FIG. III
PIG TAIL TIE

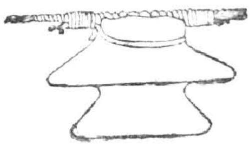


FIG. IV
STIRRUP TIE

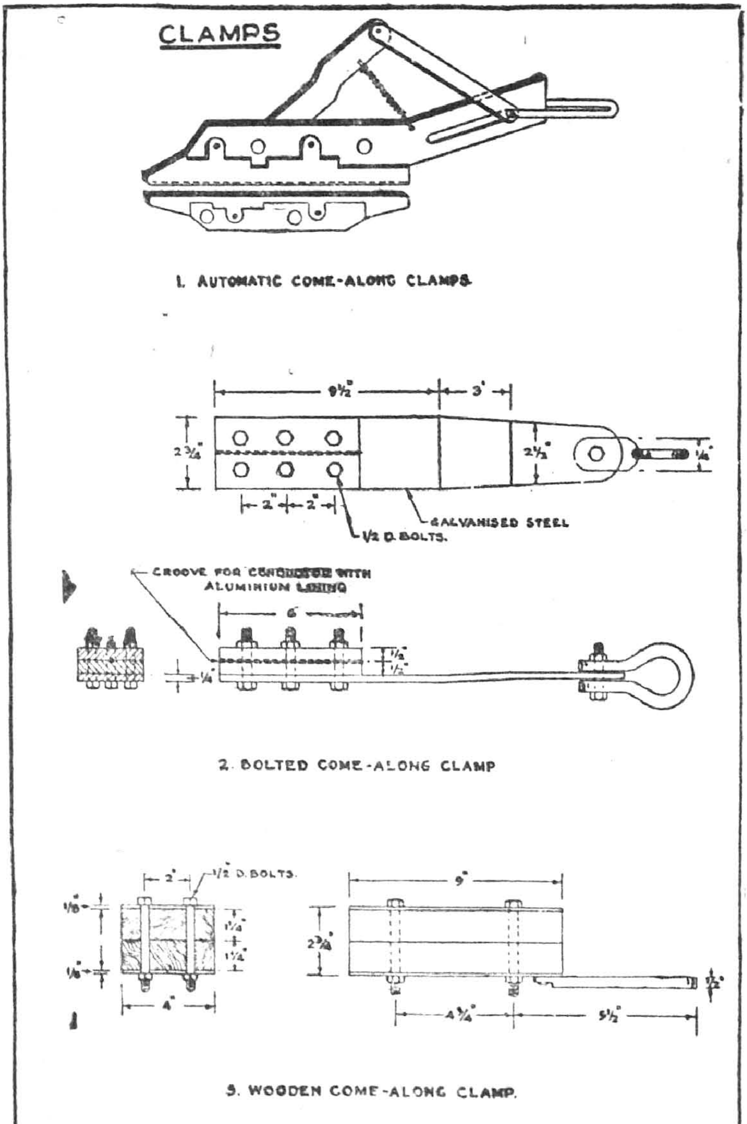

CLAMPS
1. AUTOMATIC COME-ALONG CLAMPS
9½"
3"
2¾"
2½"
¼"
2"
2"
GALVANISED STEEL
½ D. BOLTS.
GROOVE FOR CONDUCTOR WITH ALUMINIUM LINING
6"
¼"
2. BOLTED COME-ALONG CLAMP
2"
½ D. BOLTS.
1¼"
1¼"
4"
9"
2¾"
4¾"
5½"
½"
3. WOODEN COME-ALONG CLAMP.

FIG. I

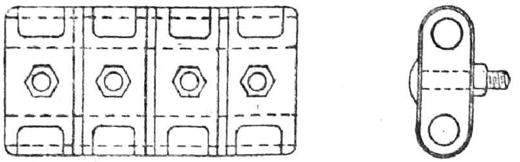


FIG. V PARALLEL GROOVE CLAMP

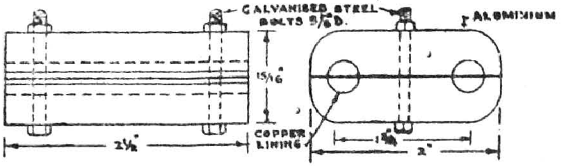
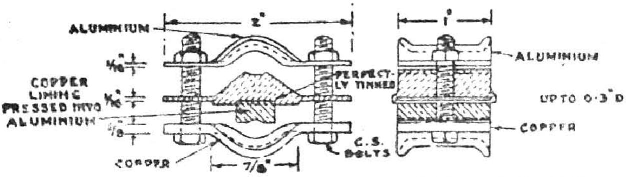
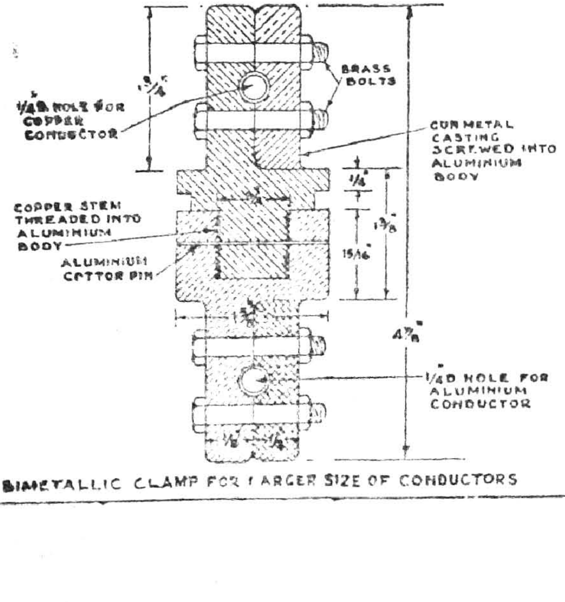


FIG. VI BIMETALLIC CLAMPS



G.E.C. MAKE UNIVERSAL TYPE - BIMETALLIC CLAMP



BIMETALLIC CLAMP FOR LARGER SIZE OF CONDUCTORS

should be so designed that as little as possible of the actual joint between the dissimilar metals is exposed, in order that the joint shall not rely entirely upon the coating of paint for its protection. Upon this principle is based the use of the simple parallel groove type bimetallic clamps, arranged with one groove lined with copper.

Types of bimetallic clamps generally are indicated in figure 8.

Experience has shown that most of the 'open jumper' faults on the line are only due to failure of the bimetallic joints, the efficiency of which depends mostly on the initial making. It should therefore be ensured that care has been taken against possibilities of ingress of moisture especially in the parallel groove type. It is said that a perfect tinning of the surface of copper to be in contact with aluminium would be remedy against the possibility of bimetallic action. As this will not be possible always, specially in the case of tapping to lines, the portion of copper to be connected on to the aluminium is wrapped with a layer of good tinned copper binding wire and then the usual binding with aluminium binding wire is given after keeping the aluminium conductor piece in position.

Practical experience has shown that the G.E.C. make of universal bimetallic clamp is a very successful one. The bimetallic clamps of this make removed from the Coimbatore-Perianaickenpalayam 22 KV lines during the conductor replacement work, did not reveal any signs of arcing, pitting, or electrolytic action. These clamps were originally put up on the lines before 1933 and have been in continuous service so far carrying an average current of about 110 amperes.

The use of tinned copper binding wire between the copper and the aluminium conductors to fight the bimetallic action has also proved a success. This type of joint was used at some locations on the Mill ring mains at Coimbatore with 6/·186+7/·062 a.c.s.r. and 19/·083 copper from trial during 1951 and the joints were examined periodically and found to be satisfactory.

Vibration problems.—Under certain conditions of operation overhead lines are susceptible to the occurrence of high frequency vibrations, which occur in the vertical plane, and have a frequency of the order of 5 to 40 cycles per second. Conductors are most likely to vibrate during steady winds of about 2 to 15 miles an hour, blowing approximately at right angles to the line. When vibrations of sufficiently high amplitudes and frequencies occur for long periods occasional cases of fatigue-breaks at points of support are experienced. The use of unsatisfactory pin bindings, clamps, or fittings has been one of the principal causes of breakage of conductors due to vibration. Another principal cause is the improper stringing of conductors resulting in excessive tension. Apart from the design and making of the proper clamps and accessories, the vibration problem has been solved by the use of special devices which fall into two groups viz., (*a*) reinforcement (*b*) dampers.

(*a*) *Reinforcement.*— In the Varney system of reinforcement, the conductor, where it lies on the groove of the insulator or the suspension clamps, is surrounded by a spiral layer of small round rods preferably tapered at each end and appreciably larger in diameter than the individual wires of the conductors. These are known as the 'carmour rods' and, in effect, they give at the point of suspension or the binding clamp a stranded cable of much larger diameter than the actual conductor, so that they provide a resistant to bending equal to that of a much larger conductor, whereas the energy, which must be absorbed by this binding, is only that produced by the wind acting on the smaller conductor itself.

In addition, these armour rods provide an excellent protection against flash-over and have been used for this purpose in various cases where no vibration was experienced or anticipated.

In the other system known as the 'Bates method' an auxiliary length of the conductor is clamped to the main conductor on either side of the building clamp. In both these systems, the reinforcement also provides some degree of damping.

(*b*) *Damper.*—A true damper is a device specially designed to absorb the vibrational energy and thereby prevent the occurrence of any vibration at all. Among the many different designs of the dampers, the Stockbridge damper shown in figure 9, which is in common use, is an extremely simple and effective device for suppressing high-frequency vibrations which may occur in overhead conductors.

The damping action of this device is due to the absorption of vibrational energy of the conductor by hysterisis and interstrand friction in the flexible damper cable. Vibration in the main conductor causes relative motion between the central clamp and weights of the damper, resulting in the bending of the flexible cable through a magnified arc and a consequent absorption of energy.

Acknowledgment.—The author is grateful to Sri K. S. Doraiswamy, Divisional Electrical Engineer, Coimbatore, who was kind enough to go through this article and give his valuable suggestions.

References.—(1) 'Overhead Transmission Lines', British Aluminium Co., Ltd.

(2) 'Development Bulletin' Aluminium Union, Limited.

Progress During The Quarter Ending 31st December 1953

Salient Features

The Department earned a revenue of Rs. 118·74 lakhs during the quarter and the working expenses including suspense and contribution to reserve amounted to 70·09 lakhs. The capital expenditure during the quarter was Rs. 38·12 lakhs.

Extension works which were held up due to financial stringency during the first half of 1953-54 were resumed and are being pushed through. Supply was given for 283 agricultural, 124 industrial and 1,542 domestic services during this quarter.

Construction Branch

Pykara Plant Extensions III Stage.—At Singara power house concreting machine foundations was completed. Erection of turbines, generators, transformers, etc. was progressing.

Madurai Thermal Scheme.—Hydraulic test on Steinmuller's boilers was carried out on 2nd October 1953 with satisfactory results.

South Kanara Scheme.—Arrangements for jungle clearance and excavating foundations of towers were being made.

Pykara-Coimbatore-Madurai 110 KV. line—(*a*) *Pykara-Coimbatore reach.*—Excavation and concreting in the plains section was completed. Tower erection and earthing have been taken up in the plains sections and about 30 per cent of tower erection and 55 per cent of earthing have been completed.

(*b*) *Coimbatore-Madurai reach.*—Conductors were strung for almost the entire reach.

Mettur Workshop Expansion Scheme.—All works connected with the workshop expansion except erection of some machinery which was in progress were completed.

Madras Plant Extensions.—All works under the first stage extensions have been nearly completed with the recommissioning of the 15 M.W. turbo set after repairs.

Under the second stage extension, erection of the second 15 M.W. turbo alternator was progressing.

Operating Systems—Hydro Systems

Generation.—The station peak load, system peak load and the units generated during the quarter were also as follows :—

Name of system Station.	*Station peak load in K.W.*	*Units generated in millions.*	*System peak load in K.W.*
Pykara	43,400	49·02	49,350
Moyar	36,000	20·63	
Mettur	42,300	71·77	47,850
Papanasam	28,000	23·40	20,700
Madurai Thermal	8,000	3·36	

The following services were connected during the quarter :—

	Agricultural.	*Industrial.*	*Domestic.*
Pykara system	192	19	611
Mettur system	42	20	102
Papanasam system	23	17	373

Hydro Generation Circle.—Improvement works to Pykara Main Flume channel to increase the capacity was in progress.

At the Madurai thermal station, the mechanical coal handling plant was commissioned.

Thermal System

Madras Electricity System—(a) Generation.—The station peak load, units generated and the system peak load were as follows :—

Name of station.	*Station peak load in K.W.*	*Units generated in millions*	*System peak load in K.W.*
'A' Station	24,000	29·629	29,700
'B' Station	12,300	6·718	
'C' Station	2,200	0·153	

(Villivakkam emergency station was not run during the quarter).

A total of 265 D. C. services were changed over to A.C. supply.

Twenty agricultural services, 68 industrial services and 456 domestic services were connected during the quarter.

Maximum relief was availed by Madras from the hydro systems during October 1953 with a view to utilise the free flows at Pykara. During November and December, 1953, however, only peak-load relief was availed from the hydro systems

and maximum relief returned to the hydro system during low load periods to conserve the hydro storage.

Accounts Branch

The voluntary loan contribution system for extension works has since been revoked by Government, priority is however being retained for such works for which capital contribution is received from the beneficiaries.

Technical Branch

Electrical.—The following were some of the more important works attended to during the quarter:—

(1) Government approval was obtained for the various erection contracts, viz. (i) turbines, (ii) generators and indoor switch-gear and (iii) transformers and outdoor switch-gear, under Pykara III Stage Extensions.

(2) Tenders were received for distribution transformers and orders placed for about 240 transformers costing Rs. 11·30 lakhs.

(3) Tenders received against the specification for lighting installation for Villivakkam sub-station under the Madras-Mettur Inter-connection scheme, were analysed and orders placed.

(4) *Madras Plant Extensions, III Stage.*—The specification for the plant to be installed was under finalisation.

(5) *Making of models for Exhibition.*—The large size models of Pykara-Moyar Scheme, and Papanasam Hydro Electric Scheme and wall models or dioramas of Mettur, Pykara-Moyar and Papanasam were completed. The Department participated in All-India Khadi Swadeshi and Industrial Exhibition, Teynampet from 23rd December 1953.

(6) Draft specification for wood poles, glass insulators, copper bars and rods for electrical purposes, H.V. tests on insulators received from the Indian Standard Institution were studied and comments were forwarded to them.

Civil.—Proposals for improvements to Pykara Flume channel for increasing its carrying capacity to 300 cusecs were finalised.

Designs for foundations for steel structures at Kumbakonam, Sankarankoil, Thalayuthu, Thirumangalam, Pollachi and Mayuram sub-stations were finalised.

Revised estimate for investigation of Kumbar-Amaravathi hydro-electric scheme has been got up and was under finalisation.

An estimate for detailed investigation of Sandyanall and Porthimund reservoirs and diversion proposals was submitted to Government (since sanctioned by Government).

Construction of measuring weirs across West Varahapallam, Upper Bhavani and Punnapuzha were in progress, that of West Varahapallam was nearing completion and that of Upper Bhavani was expected to be completed by end of January 1954.

The hydrometric surveys sub-division continued their work of recording and compiling rainfall and run-off figures for the various river basins in the State both from Government owned as well as private rain gauges and stream-flow measuring stations.

Work of the Electricity Department, 1947—53

This note gives the progress made by the Government Electricity Department, since Independence in 1947. All figures refer to the Residuary State area.

Capital outlay and revenue.	1946–47 Rs. in crores.	1952–53 Rs. in crores.
Capital outlay on plant in operation.	7·90	25·91
Capital outlay in construction.	0·57	8·83
Gross revenue earned.	1·12	4·31

It will be noticed that the capital outlay of plant in operation has trebled and the gross revenue earned quadrupled within this period. This is very substantial progress. Indeed, outlay on construction of new projects touched record figures each during this period. Furthermore, there was an outlay of Rs. 10·25 crores on construction work in 1953 which is still to be brought to operation.

The principal additions to plant were—

(1) The acquisition of the Madras City power plant and distribution in August 1947 from the private licensee.

(2) Installation of 5,000 KW of generating plant at Basin Bridge.

(3) The Madurai Thermal Scheme of 14,000 KW.

(4) Extension of the Papanasam Power Plant by 7,000 KW.

(5) Moyar Hydro Electric Project of 30,000 KW capacity.

(6) Extensions to the Basin Bridge Thermal Plant by 15,000 KW.

Before the end of 1954, further additions to the extent of 27,000 KW. to the Pykara plant and 15,000 K.W. to Basin Bridge will be commissioned into service.

Power plant in operation.—The power plant in operation compares as follows :—

	1946–47	1952–53
Installed power plant : KW.	104,000	220,000
Transmission and distribution : miles.	4,800	9,949

The power plant in operation has more than *doubled* in capacity in the interval. The transmission and distribution line mileages have also been more than *doubled*, about 5,100 miles of new lines having been built.

Power demand met and energy generated were as below :—

	1946–47	1952–53
	KW.	KW.
Power demand	65,550	143,620
	Millions.	Millions.
Units generated	298	702

Demand and consumption of energy also seem to have more than doubled themselves. The consumption would have been still more in 1952–53 if there had not been power cut due to water shortage.

Rural electrification.—Madras State leads all other States in India in the matter of rural electrification.

It is believed that the number of villages electrified in all India is around 3,500. Of these those in Madras State alone account for over 2,000.

Considering that there are 19,491 villages in this State over 10 per cent of them are already electrified.

In 1946–47, the number of villages electrified was 843 and the number in 1952–53 was 1,998. More villages could have been electrified if we had money. It is possible for the Department to keep as a target the electrification of 250 villages or even more every year provided necessary finance is made available.

The number of agricultural services, given by the Department mostly for electric pumpsets, has been growing from 5,002 in 1947 to 16,530 in 1953. Provided finance is made available, the Department can well have a target of 3,000 pumpsets for connection every year.

Rural industries run by electricity play an important role in the countryside economy. They are mostly concerned with processing of the raw products grown locally. There were 826 rural industries in 1947. Now there are over 2,038 of them.

In view of the widespread demand of the people for power, several extension schemes have been investigated and sanctioned. Their estimated cost is over Rs. 8 crores and they will be taken up in due order of priority to the extent money is available.

Industrial expansion.—About 70 per cent of the total power production in the State is used for industries and agriculture. Modern industry depends on electricity for its motive power and the progress made between 1947 and 1953 is indicated below:—

	Connected load in KW.	
	1946–47	1952–53
Industrial supplies.	1,22,500	2,33,000
Irrigation and agriculture.	40,700	93,100

Industrial load has been nearly doubled and the agricultural load more than doubled.

Important among the major industries added are the India Cement Works in Tirunelveli District, extensions to the Madukarai and Dalmia Cement Factories, and about 30 new textile mills. About 3,000 medium scale industries have also been established in the intervening period adding to the productive wealth of the country and increased employment of the people.

Power cuts.—A word is necessary about the power cuts imposed in the last few years. To meet the growing power demand in the country constant additions have to be made to the number and capacity of the power stations. The department had accordingly designed and prepared new power projects but they were all held in abeyance during the war period and construction work was at a standstill. These schemes, however got sanctioned at the end of the war and the Department, so to say, had its own *Five year plan* for the period 1946 to 1951 well launched even before the Government thought of their plan. If machinery delivery had been normal and supplies of cement and steel had come as expected all these projects

would have been completed by 1951 and there would have been no power shortage at all. Unfortunately, due to world conditions, considerable delays occurred in the delivery of machinery, cement and steel and the programme got delayed by two to three years. Simultaneously the Gods were also unkind and successive failures of Monsoons occurred resulting in acute power shortage. That was why power cuts had to be imposed in the recent years.

Thermal Stations.—People ask why thermal schemes were not thought of earlier. Actually, three thermal expansion schemes had been sanctioned by Government all in 1946.

(1) Madras 'C' station of 5,000 KW. capacity.

(2) Madras 'B' station of 30,000 KW. capacity.

(3) Madurai thermal station of 4,000/14,000 KW capacity.

There was however delay in their completion as planned. Madras 'C' station was completed in 1948 and Madurai station was in partial operation in 1951. Madras 'B' station's first 15,000 KW set was commissioned only in 1953. Madurai will be completed in the next two months and so will Madras 'B' station.

Power situation is returning to normal and as everyone is aware, there will be no power cut this summer.

Furthermore, new thermal plant of capacity 30,000 KW has been sanctioned at the Madras thermal station. There is also a project under study for a very big thermal station to be located in the lignite area in South Arcot district of capacity 100,000 KW initially and *200,000 KW later.*

Further projects.—Apart from these thermal schemes, two major hydro-electric projects have also been prepared. One is Periyar project with an initial capacity of 75,000 KW which has received the approval of the Planning Commission and will shortly be sanctioned by the Government. The other is the Kundah project, with an initial capacity of 145,000 KW. This is awaiting the consent of the Planning Commission for inclusion in the current five year plan.

Negotiations are also taking place with the Travancore Cochin Government for a bulk supply from them to us of 20,700 KW to meet our needs before these major projects get completed.

When these projects are completed the power position in the State will be considerably eased.

Conclusion.—It will be seen that the record of work of the Electricity department in the period from 1946–53 has been substantial showing as it does that, within the period,

(i) Production of energy had more than doubled;

(ii) Construction of several new projects and lines had been effected costing about Rs. 30 crores;

(iii) Rural electrification in Madras State is better than in any other State in India; and

(iv) Plans for further expansion in a large way both of thermal and hydro-electric power projects have been prepared ready for execution.

Social and Personal

With effect from 1st April 1954, Sri G. Sundaram has been appointed as Part-Time Consulting Engineer to Government (Electrical) and he assumed charge as such.

Sri V. P. Appadurai, Superintending Engineer, Technical (Electrical) was promoted as Chief Engineer for Electricity and he assumed charge as Chief Engineer for Electricity on 1st April 1954 forenoon vice Sri G. Sundaram.

Sri P. R. Sundaram, Divisional Electrical Engineer was re-appointed as Superintending Engineer (Electrical) and he assumed charge as Superintending Engineer, Technical (Electrical) vice Sri V. P. Appadurai on 31st March 1954 afternoon.

Sri K. M. Kuruvilla, Superintending Engineer, Mettur Electricity System was transferred as Superintending Engineer, Pykara Electricity System, vice C. E. Prager transferred as Superintending Engineer, Mettur Electricity System. Sri Kuruvilla took charge as Superintending Engineer, Pykara Electricity System, on 24th April 1954 afternoon and Sri C. E. Prager as Superintending Engineer, Mettur Electricity System on 3rd May 1954.

Appreciation

On the occasion of Sri V. Gopalakrishnan, Chief Head Draftsman, retiring from service on 2nd May 1954 forenoon, the Chief Engineer for Electricity wishes to place on record his appreciation of the long, able and devoted service rendered by Sri Gopalakrishnan to the Department. The good wishes of the Department go to him for his health and happiness in his retirement.

The Chief Engineer for Electricity is also pleased to place on record his appreciation of the good work done by the following officers in connection with the All-India Khadi, Swadeshi and Industrial Exhibition, Madras, held during December 1953–February 1954:—

Sri P. S. Subramanian, Excutive Engineer (Electrical).

Sri K. R. Radhakrishnan, Assistant Engineer (Electrical).

Sri C. Sanjeevi, Assistant Engineer (Electrical).

Sri V. Viswanathan, Assistant Engineer (Electrical).

Sri N. Gopalan, Junior Assistant (Administration).

Sri V. Krishnamuthi, Supervisor (Electrical), I Grade.

Sri K. Jambulingam, Junior Engineer.

S. K. Bashyam, Manager.